Simulation of a proposed Multiplicity filter for INGA

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1. Introduction

Study of nuclear structure at high spin is of paramount importance in nuclear physics. A lot of detector developments are being carried out to selectively populate very high spin states. Large array of HPGe detectors has become one of the key instrument to study high spin spectroscopy. Improved selectivity of high multiplicity gamma cascade is needed to cleanly observe very weakly populated high spin states. Higher multiplicity selection can be obtained by use of multiple ancillary detectors. The necessary features for such device is high granularity, good efficiency and sufficient solid angle coverage. Also, such device should have low cross correlation between individual detector elements to reduce false acceptance of low multiplicity events. Similar detector systems are already been used in other laboratories for the study of very high spin structures [1]. A Geant4 simulation has been carried out to investigate the performance of a proposed assembly of detectors to be used as a multiplicity selection device in association with the INGA array at TIFR.

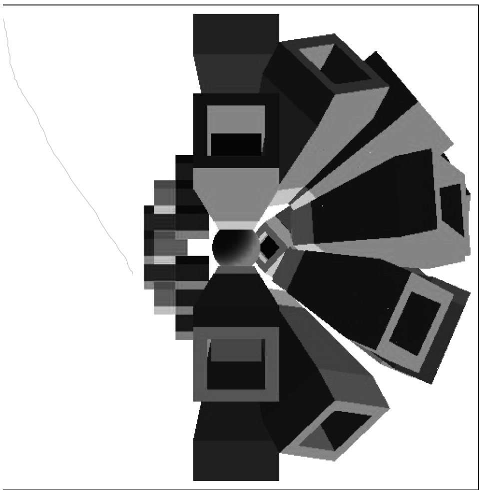

FIG. 1: Simulated geometry of a multiplicity detector array in association with backward hemisphere of INGA array at TIFR.

2. Details of Simulation

A multiplicity selection device is proposed to combine with the existing gamma ray detection array at TIFR [2]. A detailed simulation of the entire array has already been carried out [2]. In the present work, the simulated geometry used in [2] is modified with a proposed array of ancillary detectors which will replace the detectors placed in the forward angles of TIFR-INGA array. The geometry suggested in the simulation needs the forward hemisphere of the array to be replaced with an array of 30 closed packed NaI detectors. Each detector has a length and diameter 7 cm and 6 cm respectively. The array proposed here will have hexagonal NaI detectors. A three dimensional geometry of the simulated multiplicity detectors in combination with the INGA array is shown in Figure 1.

A randomly directed cascade of 40 γ-rays of 1 MeV energy with an overall isotropic angular distribution have been simulated at the center of the array. A total 10^4 such decay

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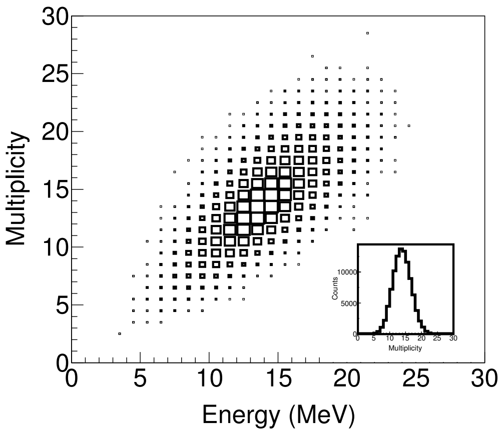

FIG. 2: A two dimensional representation of calorimetric detection of total energy of a gamma-ray cascade with observed multiplicity of events.

events were simulated. The total number of γ-rays detected simultaneously in the NaI and Clover detectors are regarded as the observed multiplicity fold for each event. Here each event represents a simulated high spin state which subsequently decays to the ground state emitting multiple γ-rays in a very short time. The multiplicity fold of γ-rays as a function of calorimetric measurement of total energy of all the observed γ-rays is plotted in Figure 2. The size of the boxes in the plot represent counts. A distribution of events surrounding multiplicity 13 and a total energy 13 MeV have been observed. The projection of the multiplicity fold of the γ-rays shown in the inset of Figure 1 has a Gaussian distribution with a mean around 13. In actual experiment a number of such cascade of different multiplicity can be produced. A detailed simulation can be used to selectively observe very high multiplicity events. The crosstalk probability is also calculated to estimate possible overestimation of multiplicity in the NaI array. For crosstalk estimation, 10^6 monochromatic 1 MeV single decay gamma-ray events are generated. An overall detection efficiency of 39% has been observed. Approximately, 2% two-fold and $< 0.1\%$ three and higher fold γ-rays were recorded. The estimated overall crosstalk probability at 1 MeV is < 4 % of the observed γ-rays.

3. Summary and Conclution

The simulation suggests effectiveness of a proposed multiplicity selection device which can be coupled with the existing array. It is worth mention here that the multiplicity selection array has to be optimized for the size of the detectors. The use of smaller detector will improve granularity. However, the crosstalk probability will increase and efficiency get reduced if smaller detectors are used. This problem can however be addressed by use of heavier materiel like BGO instead of NaI. Further, simulation work is necessary to optimize the detector volume and geometry.

References

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